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GB 1451664 GB 1358567

(58) Field of search
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(54) Security systems

(57) An electronic security system having sending units for transmitting signals representative of a condition, such as fire, intrusion, or an emergency, to a central alarm station. The sending units include detectors for producing the condition signals and an electric oscillator circuit for producing an r-f signal in an antenna (34). A feedback subcircuit of the oscillator circuit includes a surface acoustic wave resonator (SAWR) (51) for stabilizing the oscillators. A circuit including a voltage variable capacitor (64) is responsive to the condition signal to frequency modulate (FM) the r-f signal. Preferably, the condition signal is a Manchester coded digital signal and the modulation is frequency shift key (FSK).

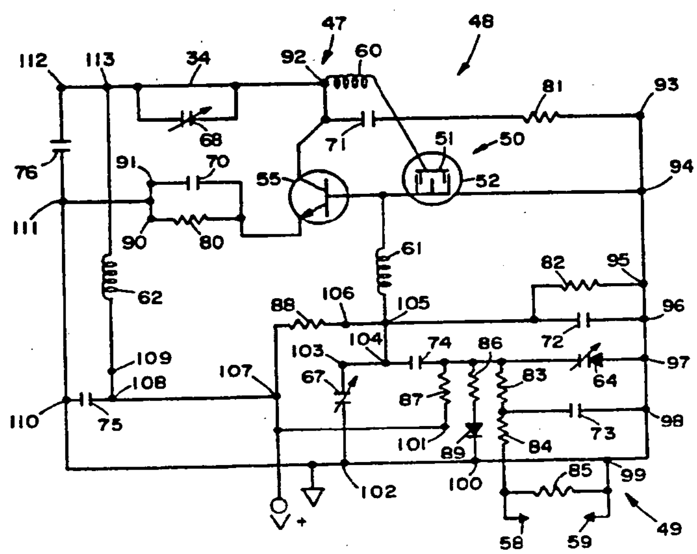

FIG. 2

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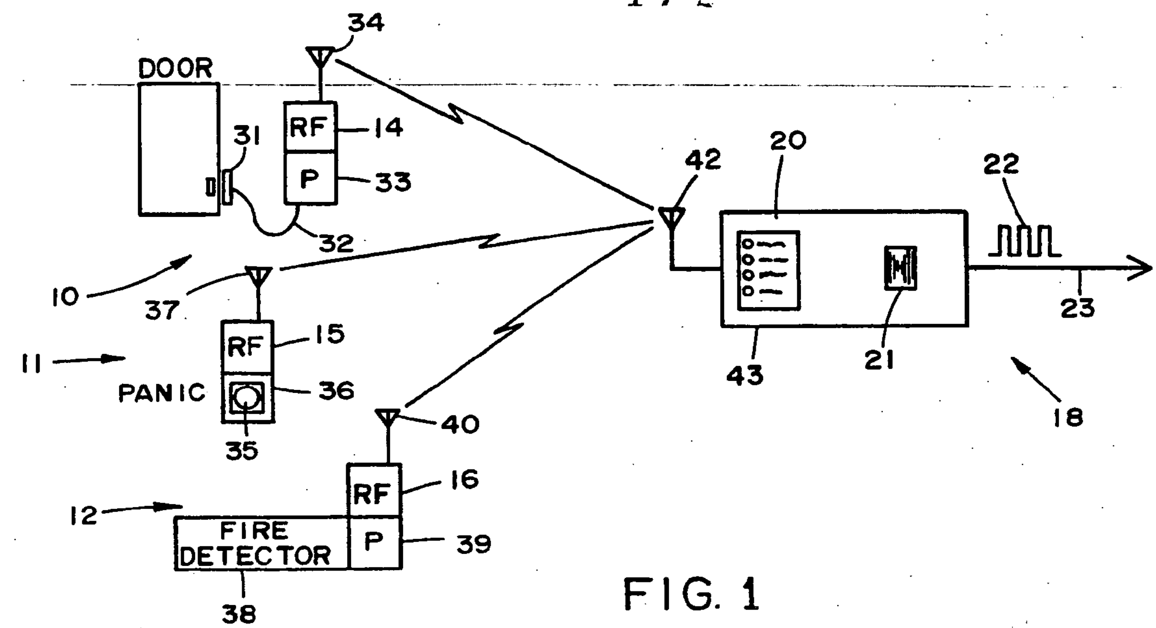

FIG. 1

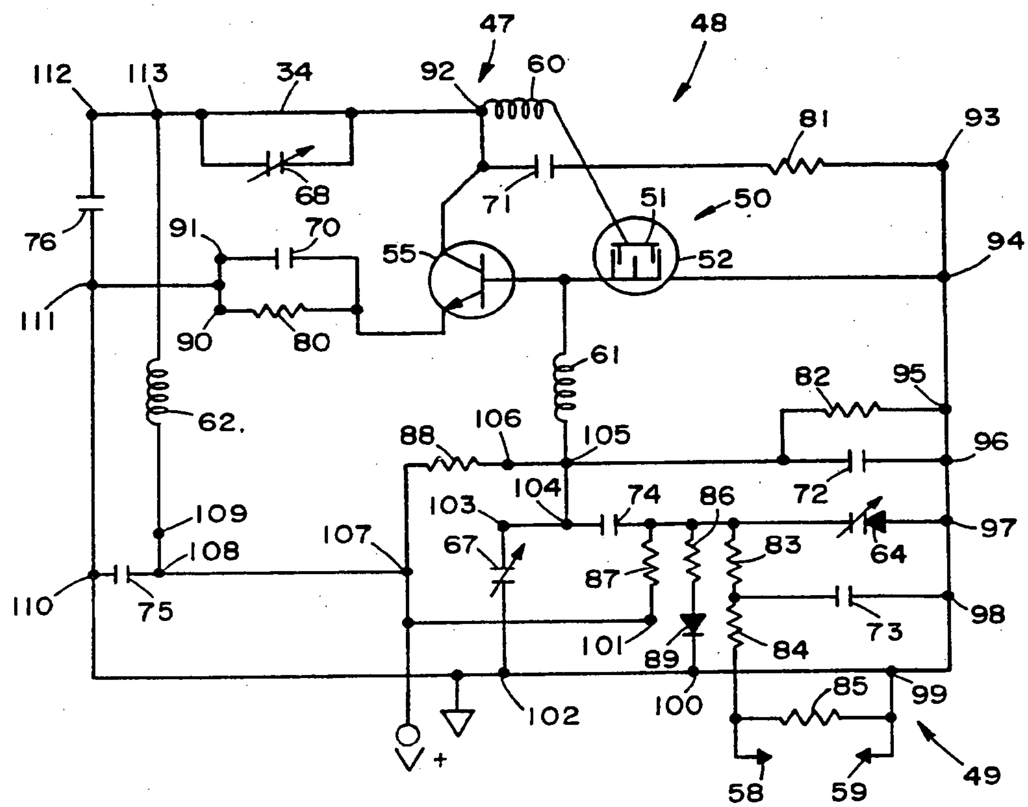

FIG. 2

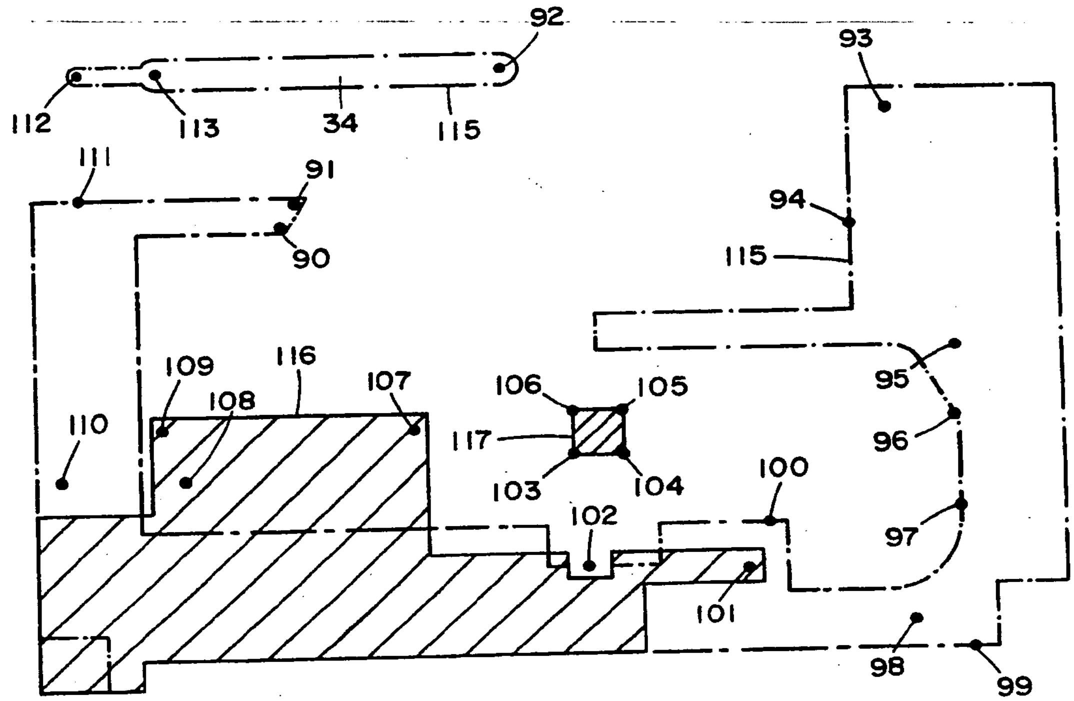
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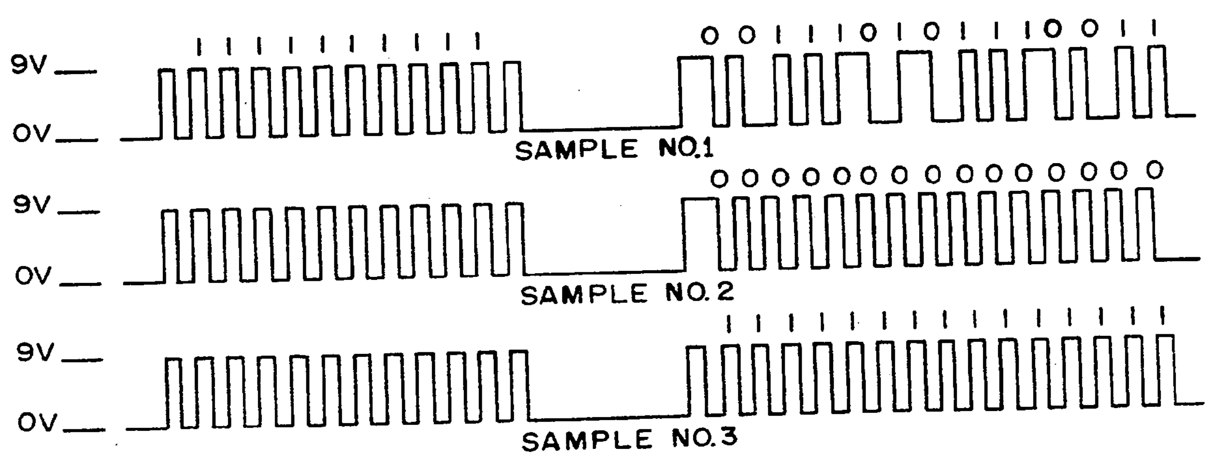
FIG. 3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0V
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9V
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SAMPLE NO.3

FIG. 4

SPECIFICATION

Security systems

The invention in general relates to security systems and in particular security systems having radio-frequency (r-f) transmitters and receivers, which are generally known in the trade as "wireless" security systems.

Security systems which include a plurality of remote sending units which transmit coded r-f signals to a central receiving station which decodes the signals to produce an alarm are well known in the art. For example, United States Patent Nos. 4,257,038, 4,110,738, 4,032,848, 3,914,692, 3,852,740, 3,833,895, and 3, 795,896 all relate to wireless security systems.

Wireless security systems employing r-f transmitters are more flexible and easier to install than wired systems which require wires to be run from each remote sending unit to the central alarm station. However, the r-f signal can give rise to other problems, in particular false alarms caused by stray r-f radiation and interference (static) which prevents the reception of the r-f alarm signal by the receiver. These problems have been made more difficult by FCC regulations which put limits on the signal strength of unlicensed transmitters, such as security transmitters. In addition, the FCC has declined to assign a frequency band for exclusive use of security systems and therefore the r-f transmitters must either compete with other r-f signals or operate in frequency ranges in which there is little r-f transmission, which generally are also frequency ranges in which it is difficult to generate suitable r-f signals.

Wireless security system manufactures have generally chosen to operate in the high frequency range above 50 megahertz to avoid interference. Designing electric oscillation circuits for such high oscillation frequencies gives rise to certain difficulties. The bulk crystal oscillators that are useful for stabilizing the oscillation at lower frequencies must be made so small that they break easily. If larger crystals are used, their frequencies must be multiplied, which consumes a great deal of power, which results in the need to change batteries in transmitters relatively frequently. Inductive/-capacitive circuits are relatively unstable and very sensitive to physical shock.

Amplitude modulated (AM) r-f signals are highly susceptible to interference from AM modulated noise, for example from thunderstorms, and therefore it is desirable that security system transmitters be FM transmitters.

Electric oscillation circuits that employ surface acoustic wave (SAW) devices are known. See for example, See Precision L-Band SAW oscillator for Satellite Application, by Thomas O'Shea et al available from Sawtek, Inc., P. O. Box 18000, Orlando, Florida 32860, which describes a SAW oscillation circuit for use in satellite receivers. Prior to the present invention, it was thought that it was not possible to build a useful FM SAW oscillator circuit.

An object of the present invention is to provide an improved security system.

The invention provides a security system comprising means for detecting a condition in a protected area and for producing a detector signal representative of the condition, an electric oscillator circuit for producing an oscillating r-f signal, the oscillator circuit including a surface acoustic wave oscillator for stabilizing the oscillations, a means responsive to the detector signal for modulating the oscillation of said oscillator circuit means, and a central station means for receiving the r-f signal and providing an output indicative of the condition in the protected area.

Preferably the surface acoustic wave oscillator is connected within a feedback circuit portion of the oscillator circuit. Preferably the feedback circuit has a Q of less than 12000. Preferably the modulation means is a frequency modulation means.

In the preferred embodiment, the oscillator circuit is modulated by modulating the capacitance of the oscillation circuit with a voltage variable capacitor. Also, in the preferred embodiment the detector signal is a Manchester coded signal and a frequency shift keyed (FSK) modulation mode is used.

Preferred systems embodying the invention significantly reduce the incidence of false alarms as compared to the prior art devices and at the same time consume relatively low amounts of power.

A Preferred securing system embodying the invention has an FM transmitter operating in a frequency range between 50 Megahertz and 1 gigahertz.

There now follows a detailed description to be read with reference to the accompanying drawings, of a security system embodying the invention. It will be realised that this system has been selected for description to illustrate the invention by way of example.

In the accompanying drawings:–

Figure 1 is a schematic illustration of a security system embodying the invention.

Figure 2 is a detailed circuit diagram of the r-f transmitter portion of the system.

Figure 3 is a diagram showing microcircuit traces of the transmitter and connections to traces; and

Figure 4 shows several examples of the data signals input into the transmitter from a signal processor.

Directing attention to Fig. 1, a security system embodying the invention is shown. This system includes three remote units 10, 11 and 12 and a central station 18. The remote units include an intrusion detector 10 on a door, a panic button unit 11, and a fire detector unit 12, each of which produce a signal

when the particular condition they are designed to detect occurs. Each remote detector unit 10, 11 and 12 has a radio frequency (r-f) transmitter 14, 15 and 16 respectively, associated with it which transmits an r-f signal which is received by the central station 18. The central station 18 decodes the signals and provides outputs, such as flashing lights 20, a siren 21, or a signal 22 over a telephone line 23 to a supervising station (not shown), which indicate the conditions detected.

Turning now to a more detailed description of the invention, the security system shown in Fig. 1 includes an intrusion detector unit 10, a panic button unit 11 and a fire detector unit 12. It is understood that the three remote units shown are exemplary. An embodiment of the invention may have only one such remote unit or it may have hundreds. Other types of detectors than intrusion, panic and fire may also be included. Remote unit 10 includes a magnetic contact device 31 on a door which is connected via wire 32 to a signal processing circuit 33. The processing circuit 33 is connected to r-f transmitter 14 which transmits a signal to central station 18 via antenna 34. Similarly, panic unit 11 comprises a panic button 35 which is connected to signal processing circuit 36, which is connected to transmitter 15, having antenna 37, and fire unit 12 comprises fire detector 38 which is connected to signal processor 39, which is connected to transmitter 16, having antenna 40. Central station 18 includes antenna 42 whch is connected to a receiver and signal processing circuitry within the chassis 43 of central station 18. The signal processing circuitry is connected to annunciator lights 20, siren 21, and a telephone line 23. It is understood that the outputs 20, 21 and 23 are exemplary only. In some embodiments, only one such output may be used or a variety of others. It is also understood that a wide variety of other signals, such as battery status signals, supervision signals, etc. may be transmitted back and forth between remote units 10, 11 and 12 and station 18.

The r-f circuit of transmitters 14, 15 and 16 is shown in detail in Fig. 2. The preferred transmitter includes surface acoustic wave (SAW) device 50, transistor 55, coils 60, 61 and 62, capacitors 70 through 76, resistors 80 through 88, and diode 89. The SAW device 50 is preferably a surface acoustic wave resonator (SAWR) 51 packaged in a protective case 52. One side of the SAWR 51 is connected to coil 60 and the other is connected to the base of transistor 55. The case 52 of the SAW device 50 is connected to ground. The emitter of transistor 55 is connected to ground through resistor 80 and capacitor 70 which are connected in parallel. The collector of transistor 55 is connected to ground through capacitor 71 and resistor 81 in series, to the other side of coil 60, and to ground through the antenna 34 (which is a trace on the microchip and shall be discussed further below) and capacitor 76. Variable capacitor 68 is connected in parallel with antenna 34. Coil 62 is connected between antenna 34 and the positive power supply voltage (V+). Capacitor 75 is connected between the positive voltage line ground. The line between the SAWR 51 and the base of transistor 55 is connected to a modulator circuit 49 generally located in the lower right corner of Fig. 2. (Insofar as the rest of the circuitry interacts with the modulation circuitry 49, it also may be considered part of the modulation circuit 49). One side of coil 61 is connected to the line between SAWR 51 and the base of transistor 55. The other side of the coil 61 is connected to ground through resistor 82 and capacitor 72 in parallel and through variable capacitor 67; the same side of coil 61 is also connected to the positive voltage line through resistor 88 and to one side of capacitor 74. The other side of capacitor 74 is connected to the positive voltage line through resistor 87, to ground through resistor 86 and diode 89 connected in series with the cathode of the diode toward ground, to ground through voltage variable capacitor 64, and to the data input line 58 through resistors 83 and 84. The line between resistors 83 and 84 is connected to ground through capacitor 73. The line 59 represents the ground side of the data input circuit. Resistor 85 is connected between data input lines 58 and 59 which connect to the signal processing circuitry (33, 36 or 39).

Turning now to Fig. 3, microcircuit traces are shown. In the preferred embodiment the circuit of Fig. 2 is placed on an integrated circuit chip or printed circuit board and the various connections are made via metallic traces printed on the chip. There are two major traces: the ground trace 115 indicated by a broken line and the positive voltage trace 116 indicated by the solid line. Traces 115 and 116 are separate on the IC chip or printed circuit board by an insulating layer. An approximately 1/8"×1" portion 34 of trace 115 acts as the r-f antenna when a printed circuit board is used. When this circuit is used in a shielded hydridized (miniaturized) circuit, a separate antenna must be used to radiate the energy outside the shield. A third trace 117 used for connecting four circuit elements is also shown. Other conventional traces as generally indicated by the remaining circuit lines of Fig. 2 are also on the chips or printed circuit boards but are not shown. The connections to the three traces shown are indicated by black dots, such as 107, and correspond to the circuit points having the same numbers on the circuit diagram of Fig. 2. The structure of the traces shown is important if the proper oscillation of the circuits is to be obtained,

although similar traces may be used and tuned to the proper oscillation frequencies as is known in the art.

In the preferred embodiment, SAW device 50 is a UHF 315 megahertz zero degree phase surface acoustic wave resonator, transistor 55 is a bi-polar type 2SC2876, and coil 60 is a 6 turn .125 inch diameter, thirteen-thirty-second inch long, air core coil made of #28 A. W. G. wire. Preferably, coil 61 is a .47 microHenry fixed coil and coil 62 is a 1.5 microHenry fixed coil. Voltage variable resistor 64 is preferably a type MV2105 AFC silicon Epicap diode (available from Motorola, Inc.), and variable capacitors 67 and 60 are 5–35 picofarad capacitors.

Capacitors 70, 73, 75 and 76 are preferably 470 picofarad while 71 is a 1000 pf, 72 is a 94 pf, and 74 is a 47 pf capacitor.

Resistors 83, 84 and 86 are preferably 100K ohm resistors, resistor 80 is a 100 ohm resistor, 81 is a 47K ohm resistor, 85 is a 600 ohm resistor and 87 is a 2 megaohm resistor. Diode 89 is a type 1N4148. The traces such as 34, are preferably of copper.

The other components of the system shown in Fig. 1 may be conventional; for example, components as described in the patents enumerated above. Preferably, however, the signal processors are programmed to produce a Manchester digital signal having a voltage level of from about zero to 5 volts at about 4 kilohertz.

The circuit functions as follows. SAWR 51, transistor 55, capacitor 76 and coil 60 from a Pierce oscillator circuit with the SAWR 51 dominating the oscillation frequency. The transistor 55 is the active amplification element. The SAWR 51 and coil 60 may be considered to be the principal elements of a feedback circuit 48. The fundamental or "centerline" frequency is preferably tuned by mechanically adjusting the separation of the turns of coil 60. The line including capacitor 71 and resistor 81 shunts the SAWR 51 indirectly, with capacitor 71 blocking DC current and resistor 81 serving as a load and a circuit Q regulator (see discussion of Q below). The shunt shortens the startup time of the oscillator circuit 47. Capacitor 75 is a bypass capacitor to prevent r-f energy from entering the modulator portion of the circuitry through ground. Coil 62 has a lower resonant frequency than the rest of the circuit and serves as a choke to prevent the antenna energy from feeding through capacitors 75 and 76 into the biasing circuitry (see below) of the transistors 55. Variable capacitor 68 may be used to tune the antenna resonant frequency. Capacitors 71, 75 and 76 are chosen to be low in capacitive resistance so as not to cause significant thermal stability problems.

The modified Pierce oscillator circuit 47 further includes coil 61 and variable capacitor 67 which, as will be further discussed below, also can be considered part of the modulation circuitry. These two elements tune both the centerline frequency of oscillation and the modulated frequency. Resistors 88 and 82 and coil 61 set the D.C. bias point for transistor 55 to determine the gain for the transistor. Resistor 80 and capacitor 70 further refine the gain adjustment, preventing degeneration of the gain in low battery situations. The modulation circuit is primarily composed of capacitor 72, 73, 74, resistors 83 through 87, variable capacitor 67 and voltage variable capacitor (VVC) 64, of which the latter is the most important element. Capacitor 72 shunts the VVC and trimmer capacitor 67. Capacitor 72 is selected to be temperature compensating for VVC 64. Capacitor 73 and resistor 84 form a filter network. Resistor 85 provides a consistent low impedance load for the incoming data signal and is sized to match the circuit used in signal processors 33, 36 or 39. The resistors 83 through 87 together form a D.C. voltage divider that helps prevent undesirable negative voltges from occurring at the cathode of VVC 64. Capacitor 74, resistor 86 and diode 89 provide a shunt line for both the trimming circut (61 and 67) and the modulation circuit, with capacitor 74 preventing D.C. current flow, resistor 86 serving as a load to prevent excessive power flow from the circuits shunted, and diode 89 acting as a voltage regulator for the resistance divider network.

The centerline frequency and the deviation frequency (the amount the frequency deviates when modulated) are preferably adjusted by trimming variable capacitor 67. The frequency may also be adjusted by trimming coil 61. The latter trimming is performed by mechanically moving the coil turns slightly in relation to one another. (In a Hybrid version of the transmitter which I have built, the mechanical trimming of the coil 61 is the preferred method of adjusting the frequencies). Coils 60 and 61 may be changed to allow for different centerline and deviation frequencies than those discussed herein. These coils play an important role in maintaining the feedback energy in a positive rather than negative phase, thus sustaining the oscillations. These coils are unique in that their Q is quite low compared to the conventional Q values that would be provided in a circuit of this type. The low Q of these coils is an important factor in obtaining the low total Q of the feedback circuit (see below).

The operation of the circuit is as follows. The oscillation of the basic r-f oscillator circuit 47 is stabilized by the feedback portion 48 of the circuit which includes SAW device 50. (The oscillation frequency may be tuned by trimming coil 61 in some embodiments). The oscillation of the feedback circuit, and thus the oscillation of the whole circuit, is modulated by the data input in the following manner. Voltage variable capacitor 64 responds to a

change in the data input voltage to change the capacitance of the modulation circuit. The changed capacitance of the modulated circuit causes its oscillation frequency to shift. The modulation circuit parallels the SAWR circuit and a change of its resonance frequency therefor causes the effective resonance of the entire circuit to change. The modulated circuit may be thought of as "pulling" the normal SAW resonance frequency to the modulated frequency. In the circuit shown, a data input voltage change of about 5 volts causes a change in oscillation frequency of about 60 to 90 kilohertz, depending on the tuning. Changes of 100 kilohertz and above have been obtained. Preferably, both the overall SAWR centerline frequency and the modulation frequency (frequency deviation) are tuned simultaneously using the variable capacitor 67 (or coil 61).

The preferred security system utilizes frequency shift keying (FSK), though other frequency modulation may be used. The signal processor, such as 33, 36 or 39, produces digital signals comprising a series of voltage transitions between a high voltage value (preferably 4 to 5 volts) and a low voltage value (preferably 0.1 to 0.4 volts). The signals are preferably Manchester encoded, which permits the synchronization with the receiver in the central station 18 to be updated regularly. Other digital encoding systems may be used, however.

Fig. 4 shows three examples of Manchester encoded signals. Each of the three samples contains a preamble portion (at the left in each sample) that is a series of Manchester encoded 1's. This preamble allows the transitter time to warm up and the receiver time to establish communication. (If a few data bits at the front end are lost, it creates no problem). Each sample also includes a central portion of zero voltage (not Manchester encoded) which provides a transition to the significant data bits which follow. Note that even where the signal is all 0's or all 1's (as in the right hand portion of sample Nos. 2 and 3 respectively) the Manchester system makes regular transitions between the low and high voltage values. This is the feature that permits the regular synchronization with the receiver.

The voltage transitions of the digital signal (Manchester or otherwise) will, as described above, cause a corresponding frequency shift of the transmitted r-f signal of the order of 60–90 kilohertz. The frequency shift is keyed on by the receiver in station 18 to recreate the digital voltage signal.

The preferred security system is more reliable than prior art security systems due to the superior frequency stabilization and low power consumption of the transmitter. The SAW stabilized transmitter does not have the temperature shifts and drift problems associated with convention LC and RC type oscillator/transmitter devices, and does not have the power supply and battery failure problems associated with the prior art bulk crystal oscillator circuits. The SAW oscillator/transmitter does not exhibit the spurious modes of oscillation that marred prior art transmitters. In addition, the power levels of the harmonic oscillation frequencies are greatly attenuated from the fundamental frequency as compared to prior art oscillator/transmitters.

The feature of the preferred system is the on-board antenna and output antenna load simulation which result in high oscillator startup reliability, which is useful in a transmitter that must start up many times from a de-energized condition. Further, the operating voltage range of the transmitter is very broad, ranging from 3V DC to 12V DC with only a slight frequency change.

An important factor in producing a workable FM SAW oscillator/transmitter is the reduction of the Quality ratios (Q) of the feedback circuit in comparison to conventional circuits. Q may be defined either in terms of bandwidths, which Q we shall refer to herein as Q_{bw}, or in terms of impedance (Z) and resistance (R) which we shall refer to herein as Q_{ZR}. It is noted that Q is a relative term and that the Q values are not equal in general. Q_{bw} may be defined as $Q_{bw}=F_o/\Delta F$ where F_o is the fundamental frequency (318 megahertz in the preferred embodiment) which is given by the equation $F_o=1/2\pi\sqrt{LC}$, where L is the inductance and C is the capacitance, and F is the frequency change in modulation (60–100 kilohertz generally in the preferred embodiment). Q_{ZR} may be defined as

$$Q_{ZR}=\frac{Z}{R}$$

with Z given by $Z=(X1-Xc)$, where X1 is the inductive reactance and Xc is the capacitive reactance, and R is the DC and skin effect resistance. Conventional transmitter design strives to maintain high Q feedback circuits. It was believed the Q_{bw} should be about 16×10^3 in feedback circuits in order to obtain suitably high output power to have an acceptable transmitter broadcast range. (The broadcast range should be at least 200 feet for security transitters). However, SAWR based oscillation circuits of high Q_{bw} tend to flip into free running modes. It is a feature of the preferred system that the Q_{bw} of the feedback circuit is unusually low, typically below 12×10^3. Preferably, Q_{bw} is about 3×10^3. It is also a feature that the coils 60, 61 are made of a wire that is much smaller in diameter than typically used in oscillation circuits of this type. Reduction of the wire diameter is important in establishing the low Q_{ZR} required for frequency pullability suitable for FSK. The reduction of the wire diameter increases the re-

sistance by limiting current and reducing the electrical cross-section thus increasing the r-f skin effect. In the SAWR circuit, the reactances, Xc and X1, generally must remain constant for a constant frequency so that resistance becomes the significant variable. With the proper biasing of transistor 55, as discussed above, broadcast ranges of up to 900 feet have been obtained, despite the low Q values. This broadest range is greater than that of the majority of prior art security systems. The FM SAW transmitter is particularly useful in a security system because it is not susceptible to the noise and interference problems that disrupt AM AW transmissions beyond usefulness.

The preferred system is manufactured on a single IC chip; previously it was not thought possible to place such a transmitter on a chip and the design of the traces referred to above is important for this.

Another feature of the preferred system is the unusually fast startup time of the SAWR transitter. Such fast startup results in less loss of data and shorter transmission times.

A further important feature of the preferred system is the relatively large shifts of frequency obtained. As indicated above, frequency shifts of 60–90 kilohertz are routine and shifts of 100 kilohertz have been obtained: it was previously thought that such high frequency shifts would cause the SAW device to go into a free running mode and not return to the fundamental frequency.

Another feature of the preferred system is the use of a variable voltage capacitor or tuning diode to modulate the SAWR circuit. It is possible with the design shown to modulate down to zero volts. This was never previously done on an FM transmitter IC chip.

Although, for clarity, the r-f transmitter circuit of Fig. 2 has been discussed in terms of an oscillator circuit 47, a feedback circuit 48, and a modulation circuit 49, it should be understood that an r-f circuit oscillates as a whole and thus from other points of view the modulation circuit may be considered to be a part of the feedback circuit and/or the oscillation circuit.

A novel security system having a frequency modulated transmitter employing a SAW device and having numerous other features has been described. It is evident that those skilled in the art may now make many uses and modifications of the specific embodiment described without departing from the inventive concepts. Many other equivalent electronic elements and materials may be used. For example, differently amplifiers may be substituted for transistor 55, other inductance combinations may be employed, different trace designs and materials may be substituted, the circuit may be made other than on a chip, and so on. Many variations of remote sending units and receiving station may be used. Many types of frequency modulation may be used and many kinds of encoding systems, digital or otherwise, may be used. Other SAW devices may be used: for example a 180 degree phase SAW oscillator has been used in a similar FM transmitter circuit.

CLAIMS

1. A security system comprising:
means for detecting a condition in a protected area and for producing a detector signal representative of said condition;
an electric oscillator circuit means for producing a oscillating r-f signal;
a surface acoustic wave device connected with said oscillator circuit for stabilizing said oscillations;
means responsive to said detector signal for modulating the oscillation of said oscillator circuit means; and
central station means for receiving said oscillating r-f signal and providing an output indicative of said condition.

2. A security system according to claim 1 wherein said means for modulating comprises a circuit means for modulating the oscillation frequency of said oscillator circuit means to produce a frequency modulated r-f signal.

3. A security system according to claim 2 wherein said electric oscillator circuit means includes a feedback circuit and said surface acoustic wave device is electrically connected within said feedback circuit to stabilize the oscillation of said oscillator means about a prescribed frequency.

4. A security system according to claim 3 wherein the Q of said feedback circuit is less than 12000.

5. A security system according to claim 2 wheren said means for modulating comprises a means for modulating the capacitance of said modulation circuit means.

6. A security system according to claim 5 wherein said means for modulating the capacitance is a voltage variable capacitor.

7. A security system according to claim 2 wherein said detector signal comprises a signal having a series of voltage transitions between a high voltage value and a low voltage value and said mean for modulating modulates the oscillation frequency of said oscillator circuit means to produce an r-f signal having frequency shifts corresponding to said voltage transitions.

8. A security system according to claim 7 wherein said detector signal comprises a Manchester coded signal.

9. A security system according to claim 7 wherein said frequency shifts are between 60 and 100 kilohertz.

10. A security system according to claim 1 wherein said oscillation frequency is in a range between 50 megahertz and one gigahertz.

11. A security system constructed, arranged and adapted to operate substantially as

hereinbefore described with reference to the accompanying drawings.

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